

Ab. 1.1301
C-2

June 1999



Physics 30

Grade 12 Diploma Examination

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June 1999

Physics 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. This examination was developed to be completed in 2.5 h; however, you may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 37 multiple-choice and 12 numerical-response questions, of equal value, worth 70% of the examination
- 2 written-response questions, of equal value, worth a total of 30% of the examination

This examination contains sets of related questions. A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

A tear-out Physics Data Sheet is included near the back of this booklet. A Periodic Table of the Elements is also provided.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.*

Instructions

- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- When performing calculations, use the values of constants provided on the tear-out sheet. Do **not** use the values programmed in your calculator.
- If you wish to change an answer, erase **all** traces of your first answer.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

- A. science
B. physics
C. biology
D. chemistry

Answer Sheet

- Ⓐ ● Ⓒ Ⓓ

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

Examples

Calculation Question and Solution

If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass will be m/s^2 .

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

$$a = \frac{F}{m}$$

$$a = \frac{121 \text{ N}}{77.7 \text{ kg}} = 15572716 \text{ m/s}^2$$

**Record 1.56 on the
answer sheet —**

1	.	5	6
	●	●	
0	0	0	0
●	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	●	5
6	6	6	●
7	7	7	7
8	8	8	8
9	9	9	9

Calculation Question and Solution

A microwave of wavelength 16 cm has a frequency, expressed in scientific notation, of $b \times 10^w$ Hz. The value of b is _____ (Record your **two-digit answer** in the numerical-response section on the answer sheet.)

$$f = \frac{c}{\lambda}$$

$$f = \frac{3.00 \times 10^8 \text{ m/s}}{0.16 \text{ m}} = 1.875 \times 10^9 \text{ Hz}$$

**Record 1.9 on the
answer sheet —**

1	.	9	
	●	•	
0	0	0	0
●	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	●	9

Correct-Order Question and Solution

When the following subjects are arranged in alphabetical order, the order is ____, ____, ____, and ____.

- 1 physics
- 2 biology
- 3 science
- 4 chemistry

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Answer: 2413

Record 2413 on the answer sheet →

2	4	1	3
•	•		
0	0	0	0
1	1	●	1
●	2	2	2
3	3	3	●
4	●	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

Scientific Notation Question and Solution

The charge on an electron is $-a.b \times 10^{-cd}$ C.
The values of a , b , c , and d are ____, ____, ____, and ____.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Answer: $q = -1.6 \times 10^{-19}$ C

Record 1619 on the answer sheet →

1	6	1	9
•	•		
0	0	0	0
●	1	●	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	●	6	6
7	7	7	7
8	8	8	8
9	9	9	●

Written Response

- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must address **all** aspects of the question.
- Descriptions and/or explanations of concepts must be correct and include pertinent ideas, diagrams, calculations, and formulas.
- Your answers must be presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.



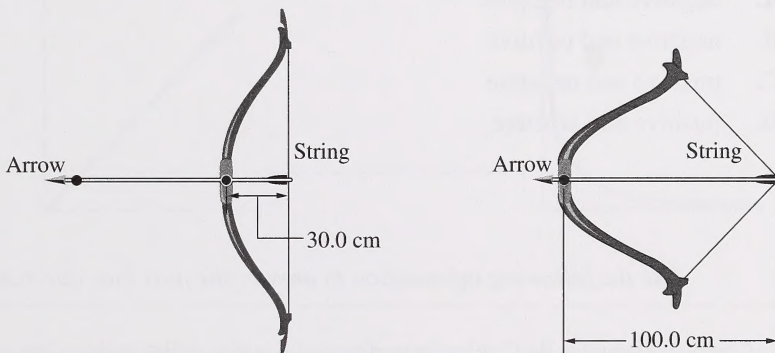
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1. Which of the following quantities are scalar quantities?

- A. Kinetic energy and potential energy
- B. Kinetic energy and momentum
- C. Potential energy and force
- D. Momentum and force

Use the following information to answer the next two questions.

A “full draw” is the maximum distance that an archer can pull back an arrow. Using the “recurve bow” shown below, a particular archer requires an average force of 130 N to pull a full draw of 70.0 cm.



2. The maximum speed of a 20.6 g arrow leaving this bow from a full draw is

- A. 66.5 m/s
- B. 94.0 m/s
- C. 4.42×10^3 m/s
- D. 8.83×10^3 m/s

*Use your recorded answer for **Multiple Choice 2** to answer **Numerical Response 1**.**

Numerical Response

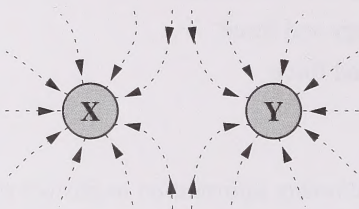
1. When the archer releases the arrow from a full draw, the magnitude of the impulse that the bow gives to the arrow is _____ N·s.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

Use the following information to answer the next question.

Electric Field Lines Near Two Charged Spheres



3. The types of charge present on X and Y are, respectively,

- A. negative and negative
- B. negative and positive
- C. positive and negative
- D. positive and positive

Use the following information to answer the next four questions.

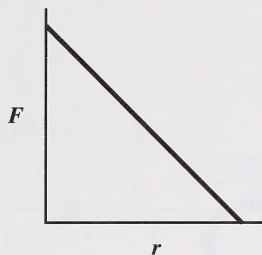
Charles Augustin de Coulomb performed a series of investigations on the quantitative nature of electrical forces. He was able to determine the effect of both distance and magnitude of charge on the electrostatic force between two charged metal spheres.

4. In order to determine the relationship between force and distance, Coulomb needed to

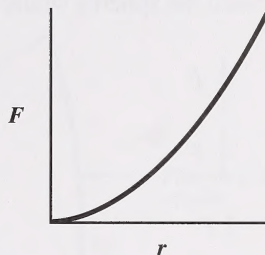
- A. keep the magnitude of one charge constant
- B. keep the magnitude of both charges constant
- C. keep the distance between the charges constant
- D. vary the magnitude of one charge while varying distance between the charges

5. Which of the following graphs represents the relationship that Coulomb determined between force and the distance between two charged metal spheres?

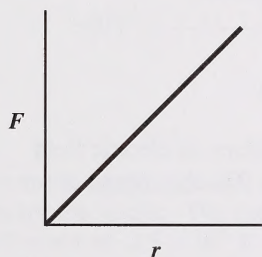
A.



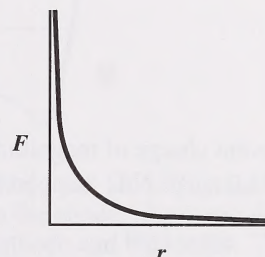
B.



C.



D.



6. Coulomb started with two identically charged spheres separated by a distance r . The force between the spheres was F . If he changed the separation to $\frac{2}{3}r$, then the force between the spheres would have become

A. $\frac{4}{9} F$

B. $\frac{2}{3} F$

C. $\frac{3}{2} F$

D. $\frac{9}{4} F$

7. Coulomb again separated the identically charged spheres by distance r . The force between the spheres was F . Coulomb touched one of the spheres with a third, identical neutral sphere. The third sphere was then moved far away from the other spheres. If he then measured the force between the original spheres, the new force between the spheres would have been

A. $\frac{1}{2} F$

B. $\frac{1}{4} F$

C. $2 F$

D. $4 F$

8. A point charge of magnitude $6.9 \times 10^{-5} \text{ C}$ produces an electric field of $1.0 \times 10^3 \text{ N/C}$ at point P. The distance from P to the charge is

A. $4.3 \times 10^{-2} \text{ m}$

B. $2.1 \times 10^{-1} \text{ m}$

C. $2.5 \times 10^1 \text{ m}$

D. $6.2 \times 10^2 \text{ m}$

9. During a lightning strike, 30 C of charge may move through a potential difference of $1.0 \times 10^8 \text{ V}$ in $2.0 \times 10^{-2} \text{ s}$. The total energy released by this lightning bolt is

A. $3.0 \times 10^9 \text{ J}$

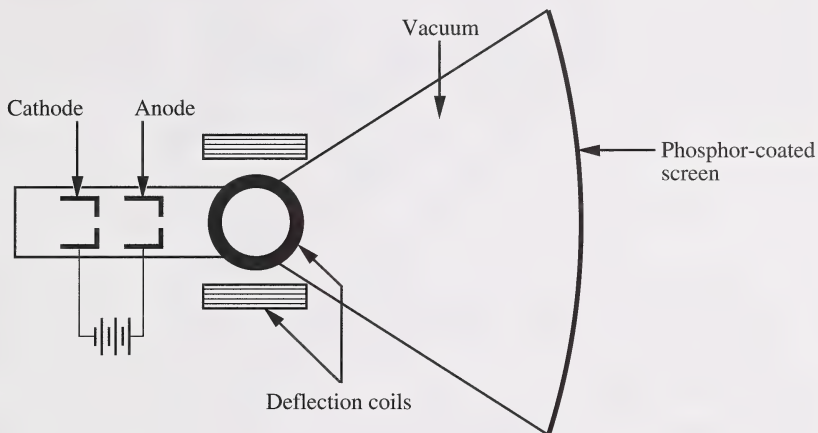
B. $6.0 \times 10^7 \text{ J}$

C. $3.3 \times 10^6 \text{ J}$

D. $1.5 \times 10^3 \text{ J}$

Use the following information to answer the next two questions.

Cathode-ray tubes (CRTs) are used for television and computer screens. They are set up as shown below.



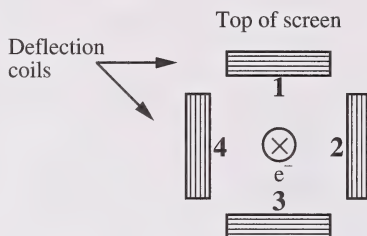
Electrons are “boiled off” the surface of the cathode and are accelerated toward the anode. The cathode is 4.5 cm from the anode. A potential difference of 2.5×10^3 V exists between the cathode and the anode. The electrons are deflected both side to side and up and down by pairs of magnetic deflection coils mounted on the neck of the tube.

10. An electron hits the screen at a speed of

- A. 1.0×10^7 m/s
- B. 1.5×10^7 m/s
- C. 3.0×10^7 m/s
- D. 8.8×10^{14} m/s

Use the following additional information to answer the next question.

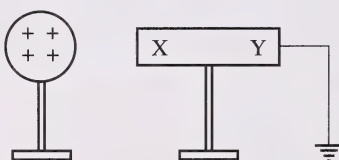
An electron is travelling perpendicular to the magnetic deflection coils, into the page, as shown below.



11. The coils that can produce a deflection toward the top of the screen are numbered
- A. 1 and 3
 - B. 2 and 4
 - C. 1 and 2
 - D. 3 and 4

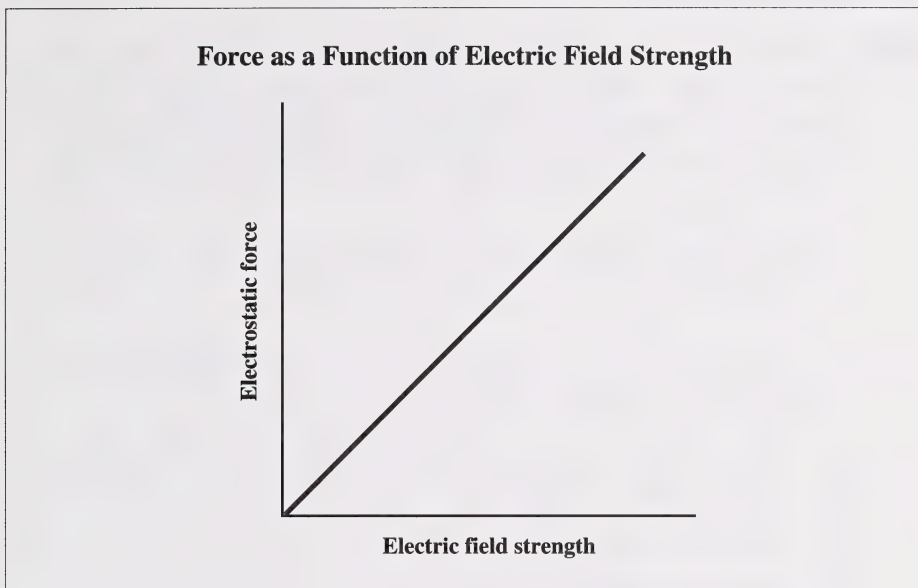
Use the following information to answer the next question.

A student places a positively charged sphere near a metal rod. Both are on insulated stands and the rod is grounded.



12. The distribution of charge on the rod is
- A. positive at end X and electrons move off the rod into the ground
 - B. negative at end X and electrons move off the rod into the ground
 - C. positive at end X and electrons move onto the rod from the ground
 - D. negative at end X and electrons move onto the rod from the ground

Use the following information to answer the next question.



13. The slope of the graph represents
- A. Coulomb's Law
 - B. the distance between two parallel charged plates
 - C. the magnitude of the charge on a particle in an electric field
 - D. the potential difference between two points in an electric field
-
14. A photon exhibits properties of a particle because it has
- A. mass
 - B. momentum
 - C. a constant speed
 - D. a fixed frequency

Numerical Response

2. Two microwave transmissions are sent at the same time on different routes to a receiving station. One route is 2 480 km longer than the other. The expected time between receiving the first transmission and receiving the second transmission, expressed in scientific notation, is $b \times 10^{-w}$ s. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

15. An automobile's battery delivers a steady DC current to a headlight. The electric current in the wire produces a circular
- A. electric field around the wire
 - B. magnetic field around the wire
 - C. gravitational field around the wire
 - D. electromagnetic field around the wire

Numerical Response

3. A wire that is 75.0 cm long carries a current of 6.00 A. The wire is at right angles to a uniform magnetic field and experiences a magnetic force of 0.350 N. The magnitude of the magnetic field, expressed in scientific notation, is $b \times 10^{-w}$ T. The value of b is _____.

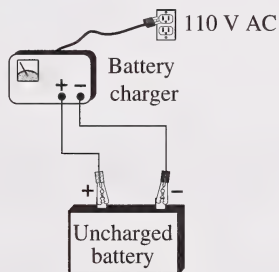
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

16. The effective voltage of an AC household outlet is 117 V. The maximum voltage across a lamp connected to the outlet is
- A. 82.7 V
 - B. 117 V
 - C. 165 V
 - D. 330 V

17. Regions of the electromagnetic spectrum listed in order from largest to smallest wavelength are
- A. X-ray, ultraviolet, visible, infrared, radio
 - B. X-ray, infrared, visible, ultraviolet, radio
 - C. radio, ultraviolet, visible, infrared, X-ray
 - D. radio, infrared, visible, ultraviolet, X-ray
18. Electromagnetic radiation is produced by charged particles that are moving
- A. at the speed of light
 - B. with zero acceleration
 - C. with a changing velocity
 - D. parallel to a fixed magnetic field

Use the following information to answer the next question.

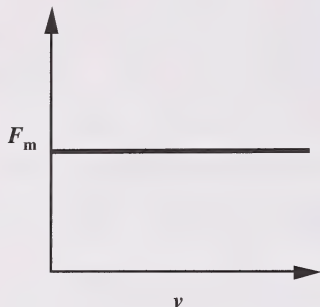
In an automobile battery charger, 110 V of household voltage is converted to 14 V DC. The efficiency of the charger is 75%.



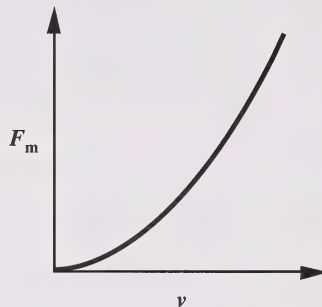
19. The initial direct current supplied to an uncharged battery by 0.70 A of household current is
- A. 6.7×10^{-2} A
 - B. 8.9×10^{-2} A
 - C. 4.1 A
 - D. 5.5 A

20. In a certain experiment, the speed of a charged particle is made to increase as it moves at right angles to a uniform magnetic field. A graph that represents the relationship between magnetic force and speed is

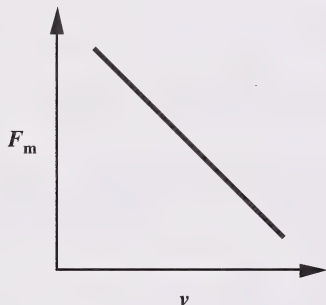
A.



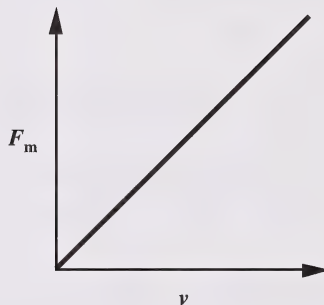
B.



C.



D.



Use the following information to answer the next question.

In 1991, the 18.0 GHz region of the electromagnetic spectrum was used to provide communication links in local area networks (LANs). This led to a dramatic expansion of this region's commercial use.

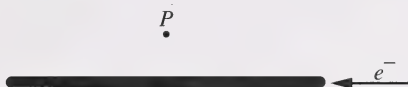
Numerical Response

4. The wavelength of an 18.0 GHz wave, expressed in scientific notation, is $b \times 10^{-w}$ m. The value of b is _____.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

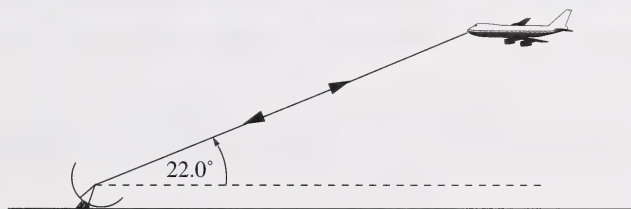
Electrons move through a wire as shown below.



21. What is the direction of the magnetic field at point P ?

- A. Into the page
- B. Out of the page
- C. Toward the top of the page
- D. Toward the bottom of the page

Use the following information to answer the next question.



A radar pulse projected at an angle of elevation of 22.0° is reflected from an aircraft and returned. (Note: The diagram is not drawn to scale. The height of the radar transmitter/receiver can be ignored.)

Numerical Response

5. If the pulse takes 1.28×10^{-4} s to make the round trip, then the vertical height of the aircraft is _____ km.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next three questions.

A proton with an energy of 894 eV travels perpendicular to a magnetic field and moves in a circular path with a radius of 3.60×10^{-4} m.

22. The speed of the proton is

- A. 4.14×10^5 m/s
- B. 1.77×10^7 m/s
- C. 1.71×10^{11} m/s
- D. 3.14×10^{14} m/s

Use your recorded answer from **Multiple Choice 22** to answer **Numerical Response 6**.*

Numerical Response

6. The strength of the magnetic field, expressed in scientific notation, is $a.bc \times 10^d$ T. The values of *a*, *b*, *c*, and *d* are _____, _____, _____, and _____.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

23. An alpha particle and a proton enter a magnetic field at the same speed. The radius of the alpha particle's path is

- A. half the radius of the proton's path
- B. the same as the radius of the proton's path
- C. twice the radius of the proton's path
- D. four times the radius of the proton's path

24. Which of the following expressions that deal with electromagnetic waves has a constant value?
- A. λ
 - B. f
 - C. $f\lambda$
 - D. f/λ

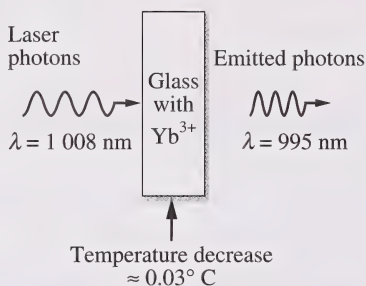
Use the following information to answer the next two questions.

Mass spectrometers are used in archeological studies to help date ancient artifacts. The relative amounts of carbon-12 and carbon-14 isotopes in a sample of organic material may be used to determine the age of the sample. Carbon-14 is a radioactive isotope that undergoes beta decay and has a half-life of 5 730 years.

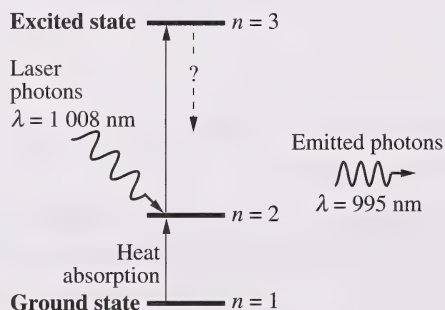
25. The product of the carbon-14 decay is
- A. ${}^{14}_7\text{N}$
 - B. ${}^{14}_8\text{O}$
 - C. ${}^{10}_4\text{Be}$
 - D. ${}^{12}_6\text{C}$
26. An archeological sample is dated using the carbon-14 dating process and is found to be 2 865 years old. What percentage of the original carbon-14 remains?
- A. 25.0%
 - B. 29.3%
 - C. 70.7%
 - D. 75.0%

Use the following information to answer the next four questions.

Physicists have produced “optical cooling” by shining a laser onto glass that contains ytterbium ions (Yb^{3+}). The glass with ytterbium ions absorbs the laser photons and radiates photons with a shorter wavelength, as shown below. This process decreases the temperature of the glass with ytterbium ions.



One theory suggests that the cooling occurs because of electron movement between energy levels in the ytterbium ions, as shown below. If a ground state electron in an ytterbium ion absorbs a small amount of thermal energy, it moves to the second energy level ($n = 2$). The ion then absorbs the laser photon, which moves the electron to the excited state ($n = 3$). The cooling occurs when the ytterbium ion emits a photon.



27. When the glass cools, the ions lose both the thermal energy and the energy that was absorbed from the laser photons. The electron energy level transition that occurs is from energy level
- A. $n = 3$ to $n = 2$
 - B. $n = 3$ to $n = 1$
 - C. $n = 2$ to $n = 1$
 - D. $n = 2$ to $n = 3$

Numerical Response

7. The frequency of the laser photons, expressed in scientific notation, is $a.b \times 10^{cd}$ Hz. The values of a , b , c , and d are _____, _____, _____, and _____.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

28. The energy difference between a laser photon and an emitted photon is
- A. 2.00×10^{-19} J
 - B. 1.97×10^{-19} J
 - C. 2.58×10^{-21} J
 - D. 8.62×10^{-33} J
29. Visible light has frequencies that range between 4.3×10^{14} Hz (red) and 7.5×10^{14} Hz (violet). Which of the following statements **best** describes the absorbed laser photon and the emitted photon in the optical cooling experiment?
- A. Both photons are in the infrared range.
 - B. Both photons are in the ultraviolet range.
 - C. Both photons are in the visible light range.
 - D. One photon is in the visible light range, and one is not in the visible light range.

30. In certain scattering experiments, alpha particles bounce backward from a thin metal target. This observation led to the hypothesis that
- A. alpha particles carry electric charges
 - B. charge is uniformly distributed throughout the atom
 - C. alpha particles' kinetic energy cannot be converted to potential energy
 - D. the centre of the atom is very small, charged, and contains most of the atom's mass

Numerical Response

8. The work function of a metal with a threshold frequency of 1.1×10^{15} Hz, expressed in scientific notation, is $a.b \times 10^{-cd}$ J. The values of a , b , c , and d are _____, _____, _____, and _____.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

31. When a neutral meson particle (π^0) decays, it produces an electron (e^-). In this process, it is **most likely** that
- A. nothing else is produced
 - B. a gamma ray is also produced
 - C. a negative particle is also produced
 - D. a positive particle is also produced

Use the following information to answer the next question.

Compton determined that the energy and momentum of a photon are related according to the formula $E = pc$.

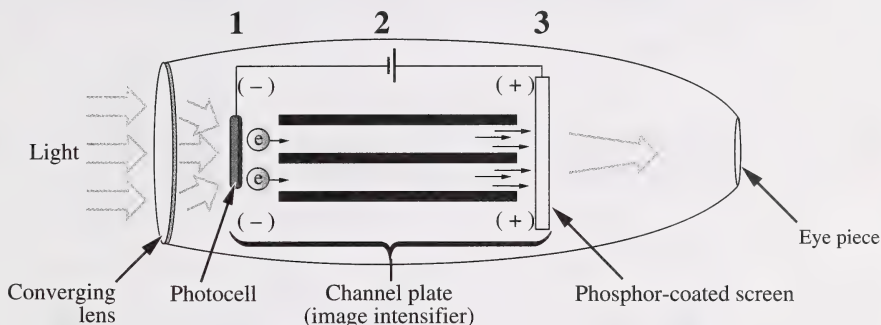
Numerical Response

9. A photon has a momentum of 4.0×10^{-23} N·s. The frequency of the photon, expressed in scientific notation, is $a.b \times 10^{cd}$ Hz. The values of a , b , c , and d are _____, _____, _____, and _____.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next three questions.

Night vision devices operate by taking available ambient light, such as starlight, and converting it into an electrical signal that is then amplified within a channel plate (image intensifier). The electrical signal is then focused on a phosphor-coated screen that emits a green image.



32. When light falls on the device at position 1 in the diagram,
- A. the Compton effect occurs
 - B. the photoelectric effect occurs
 - C. light refraction and diffraction occurs
 - D. light diffraction and interference occurs
33. Night vision devices have a built-in brightness protection circuit to protect both the device and the viewer from unexpected bright light. The circuit is activated when the
- A. photoelectric current increases
 - B. photoelectric current decreases
 - C. kinetic energy of photoelectrons increases
 - D. kinetic energy of photoelectrons decreases

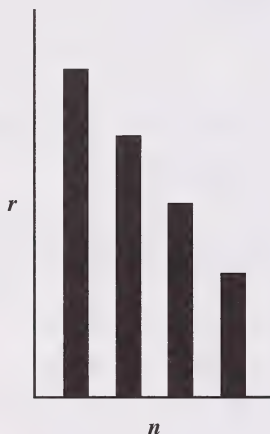
Numerical Response

10. Green light with a wavelength of 545 nm reaches the observer's eyes. The energy of a photon of this green light is _____ eV.

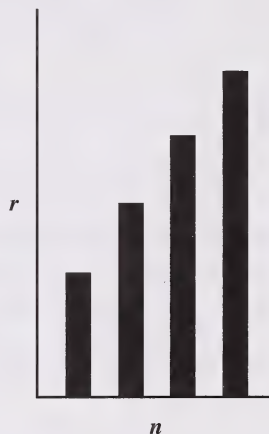
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

34. The graph below that shows the relationship between the radius of a hydrogen atom (r) and the energy level (n) of its electron is

A.



B.



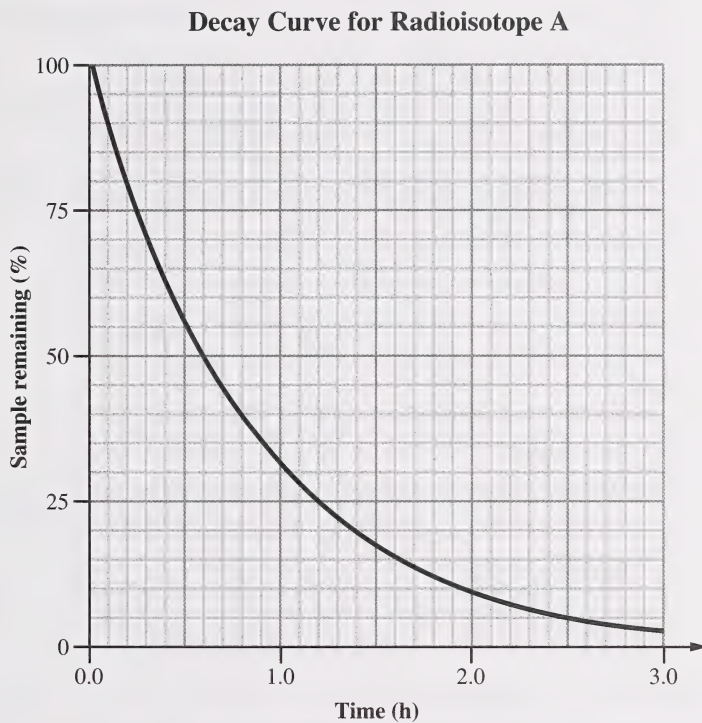
C.



D.



Use the following information to answer the next question.



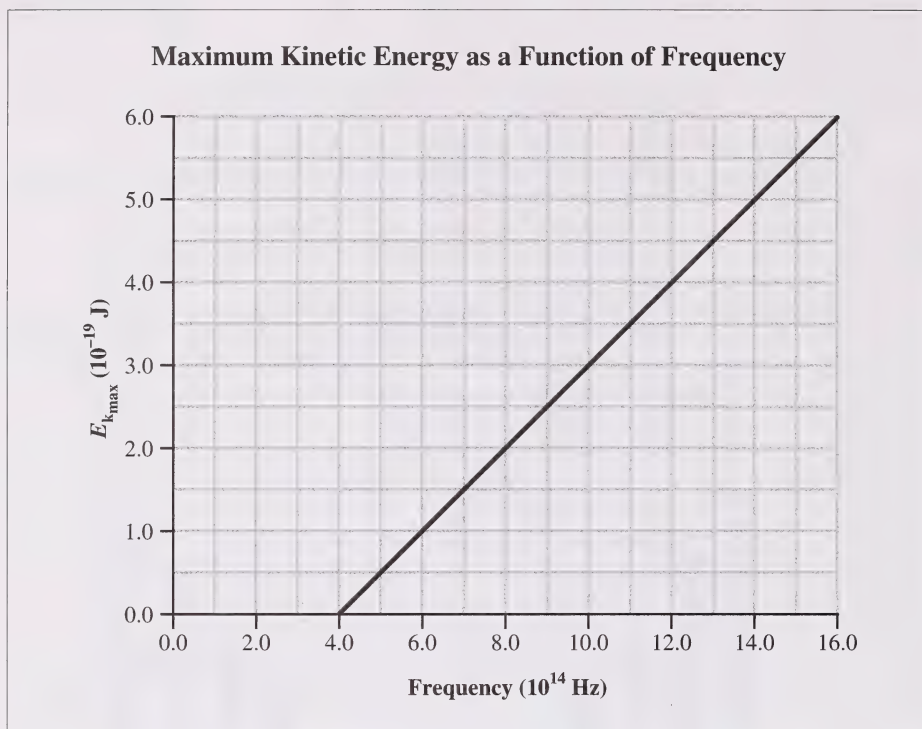
The graph illustrates the decay of a radioactive isotope.

Numerical Response

- 11.** The time required for a 40.0 g sample to decay to 1.25 g is _____ h.

(Record your **two-digit answer** in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

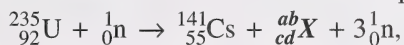


35. Based on the graph above, Planck's constant has a value of

- A. $6.6 \times 10^{-34} \text{ J}\cdot\text{s}$
- B. $5.0 \times 10^{-34} \text{ J}\cdot\text{s}$
- C. $3.6 \times 10^{-34} \text{ J}\cdot\text{s}$
- D. $3.0 \times 10^{-34} \text{ J}\cdot\text{s}$

Use the following information to answer the next three questions.

A particular nuclear fission reaction of uranium-235 is represented by



where element X is unknown.

36. The value of cd in the above reaction can be identified using the Law of Conservation of
- A. Mass
 - B. Energy
 - C. Charge
 - D. Momentum

Numerical Response

12. The fission product in this reaction is represented by ${}_{cd}^{ab}\text{X}$.
The values of a , b , c , and d are _____, _____, _____, and _____.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

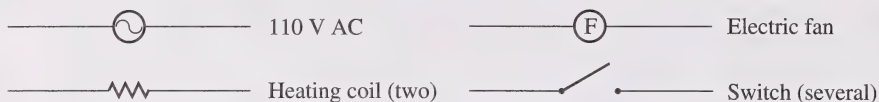
37. In the above fission reaction, the mass of the reactants is 236.05 atomic mass units, and the mass of the products is 235.86 atomic mass units. Which of the following explanations **best** describes the change in mass that occurs in this nuclear fission reaction?
- A. Mass and energy are equivalent, and energy has been converted into mass in this reaction.
 - B. Mass and energy are equivalent, and mass has been converted into energy in this reaction.
 - C. Mass and energy are equivalent, and the missing mass is due to inaccurate laboratory measuring equipment.
 - D. Neutrinos that are given off in the fission reaction are undetectable, which accounts for the differences in mass of the detectable components of the reaction.

Written-response question 1 begins on page 22.

Use the following information to answer the next question.

You have the following components: an electric fan, two heating coils, several switches, and connecting wires. These components are to be used to construct a hair dryer.

Schematics of Hair Dryer Components



The design requirements for your hair dryer are that the fan is always on when the hair dryer is on and that it has two heat settings: high and low.

Written Response — 15%

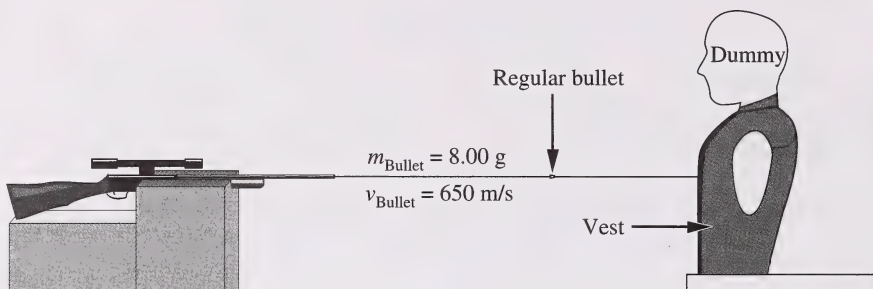
1. • Draw a schematic diagram of a hair dryer circuit that meets the design requirements.
- Based on the circuit diagram you have drawn, analyze the operation of the hair dryer. In your response, explain how the switch settings and their locations in the circuit control the low and high heat settings. Also, explain why the hair dryer should be designed so that the fan is on whenever the hair dryer is on.

Note: Marks will be awarded for the physics principles used in your response and for the effective communication of your response.

Written-response question 2 begins on the next page.

Use the following information to answer the next question.

Several Canadian companies are redesigning and testing bulletproof vests. One company does a test that involves firing a target rifle at a crash test dummy wearing a vest.



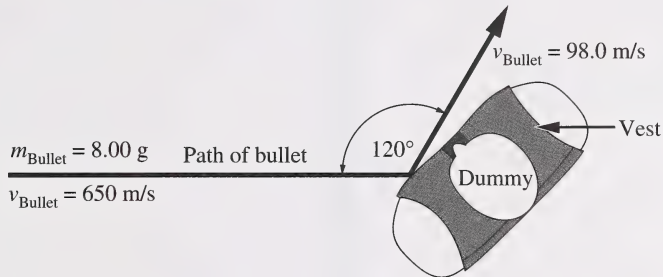
The company is testing the vests with both regular bullets and armour-piercing bullets. The armour-piercing bullet travels 1.20 times faster and has 1.20 times the mass of the regular bullet shown above.

Written Response — 15%

- 2.
- Quantitatively compare the kinetic energy of the armour-piercing bullet with the kinetic energy of the regular bullet.
 - How much energy is released by the explosion of the gunpowder if the transfer of energy from the explosion to the regular bullet is 90.0% efficient?
 - The regular bullet is in the rifle barrel for $1.42 \times 10^{-3} \text{ s}$. What is the average force exerted on the regular bullet by the expanding gases?

Use this additional information to answer the next part of the question.

A second test performed by the company has the regular bullet strike the vest at a glancing angle. The mass of the vest and the dummy is 56.0 kg. The bullet–vest collision is inelastic.



- Determine the resultant **speed** of the vest and the dummy following the glancing collision shown above.

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

deca

*You have now completed the examination.
If you have time, you may wish to check your answers.*

Vector \vec{R}

PHYSICS DATA SHEET

CONSTANTS

Gravity, Electricity, and Magnetism

Acceleration Due to Gravity or Gravitational Field Near Earth.....	a_g or $g = 9.81 \text{ m/s}^2$ or 9.81 N/kg
Gravitational Constant.....	$G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$
Mass of Earth.....	$M_e = 5.98 \times 10^{24} \text{ kg}$
Radius of Earth.....	$R_e = 6.37 \times 10^6 \text{ m}$
Coulomb's Law Constant.....	$k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
Electron Volt.....	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$
Elementary Charge.....	$e = 1.60 \times 10^{-19} \text{ C}$
Index of Refraction of Air.....	$n = 1.00$
Speed of Light in Vacuum.....	$c = 3.00 \times 10^8 \text{ m/s}$

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen.....	$E_1 = -2.18 \times 10^{-18} \text{ J}$ or -13.6 eV
Planck's Constant.....	$h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s}$ or $4.14 \times 10^{-15} \text{ eV}\cdot\text{s}$
Radius of 1st Bohr Orbit of Hydrogen	$r_1 = 5.29 \times 10^{-11} \text{ m}$
Rydberg's Constant for Hydrogen.....	$R_H = 1.10 \times 10^7/\text{m}$

Particles

	Rest Mass	Charge
Alpha Particle	$m_\alpha = 6.65 \times 10^{-27} \text{ kg}$	α^{2+}
Electron.....	$m_e = 9.11 \times 10^{-31} \text{ kg}$	e^{-}
Neutron.....	$m_n = 1.67 \times 10^{-27} \text{ kg}$	n^0
Proton.....	$m_p = 1.67 \times 10^{-27} \text{ kg}$	p^{+}

Trigonometry and Vectors

$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$	For any Vector \vec{R}
$\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}}$	$R = \sqrt{R_x^2 + R_y^2}$
$\tan \theta = \frac{\text{opposite}}{\text{adjacent}}$	$\tan \theta = \frac{R_y}{R_x}$
$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$	$R_x = R \cos \theta$
$c^2 = a^2 + b^2 - 2ab \cos C$	$R_y = R \sin \theta$

Prefixes Used With SI Units

Prefix	Symbol	Exponential Value	Prefix	Symbol	Exponential Value
pico.....	p.....	10^{-12}	tera.....	T.....	10^{12}
nano.....	n.....	10^{-9}	giga.....	G.....	10^9
micro.....	μ	10^{-6}	mega.....	M.....	10^6
milli.....	m.....	10^{-3}	kilo.....	k.....	10^3
centi.....	c.....	10^{-2}	hecto.....	h.....	10^2
deci.....	d.....	10^{-1}	deca.....	da.....	10^1

EQUATIONS

Kinematics

$$\vec{v}_{\text{ave}} = \frac{\vec{d}}{t}$$

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

$$\vec{d} = \vec{v}_i t + \frac{1}{2} \vec{a} t^2$$

$$v_f^2 = v_i^2 + 2ad$$

$$v = \frac{2\pi r}{T}$$

Dynamics

$$\vec{F} = m\vec{a}$$

$$\vec{F}\Delta t = m\Delta\vec{v}$$

$$\vec{F}_g = m\vec{g}$$

$$F_t = \mu F_N$$

$$\vec{F}_s = -k\vec{x}$$

$$\frac{\lambda_1}{2} = l; \frac{\lambda_1}{4} = l$$

$$v = f\lambda$$

$$m = \frac{h_i}{h_0} = \frac{-d_i}{d_0}$$

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i}$$

Waves and Light

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T = \frac{1}{f}$$

$$\lambda = \frac{xd}{nl}$$

$$\lambda = \frac{d\sin\theta}{n}$$

Quantum Mechanics and Nuclear Physics

$$E = mc^2$$

$$p = \frac{h}{\lambda}$$

$$p = \frac{hf}{c}; E = pc$$

Electricity and Magnetism

$$F_e = \frac{kq_1q_2}{r^2}$$

$$V = IR$$

$$P = IV$$

$$I = \frac{q}{t}$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$F_m = IIB_{\perp}$$

$$F_m = qvB_{\perp}$$

$$V = I\omega B_{\perp}$$

$$V = \frac{\Delta E}{q}$$

$$R = R_1 + R_2 + R_3$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$V_{\text{eff}} = 0.707 V_{\text{max}}$$

$$I_{\text{eff}} = 0.707 I_{\text{max}}$$

Atomic Physics

$$hf = E_{k_{\text{max}}} + W$$

$$W = hf_0$$

$$E_{k_{\text{max}}} = qV_{\text{stop}}$$

$$E = hf = \frac{hc}{\lambda}$$

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

$$E_n = \frac{1}{n^2} E_1$$

$$r_n = n^2 r_1$$

$$N = N_0 \left(\frac{1}{2} \right)^n$$

Momentum and Energy

$$\vec{p} = m\vec{v}$$

$$W = Fd$$

$$W = \Delta E = Fd \cos \theta$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

$$E_k = \frac{1}{2} mv^2$$

$$E_p = mgh$$

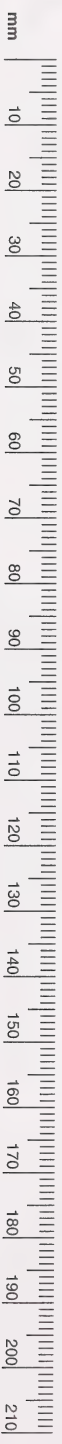
$$E_p = \frac{1}{2} kx^2$$

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
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1 H 1.01 hydrogen	3 Li 6.94 lithium	4 Be 9.01 beryllium	5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen	9 F 19.00 fluorine	10 Ne 20.17 neon	11 Na 22.99 sodium	12 Mg 24.31 magnesium	13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.06 sulphur	17 Cl 35.45 chlorine	18 Ar 39.95 argon	19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.90 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.71 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.72 gallium	32 Ge 72.59 germanium	33 As 74.92 arsenic	34 Se 78.96 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton	37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.94 molybdenum	43 Tc (98.91) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.40 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.69 tin	51 Sb 121.75 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.30 xenon	55 Cs 132.91 cesium	56 Ba 137.33 barium	57-71 La 138.91 lanthanum	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.85 tungsten	75 Re 186.21 rhenium	76 Os 190.20 osmium	77 Ir 192.22 iridium	78 Pt 195.09 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.37 thallium	82 Pb 207.19 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (209.98) astatine	86 Rn (222.02) radon	87 Fr (223.02) francium	88 Ra (226.03) radium	89-103 Ac (227.03) actinium	104Unq (266.11) unnilquadium	105Unp (262.11) unnilpentium	106Unh (263.12) unnilhexum	107Uns (262.12) unnilseptium	108Uno (265) unniloctium	109Une (266) unnilennium	110Uuh (276) unnilunium	111Uhs (278) unnilhassium	112Uht (285) unniltetradium	113Uhu (284) unnilpentium	114Uhf (289) unnilhexium	115Ufl (288) unnilseptium	116Ufs (294) unniloctium	117Ufb (293) unnilenneum	118Uft (294) unnilunium	119Ufl (294) unnilhassium	120Ufh (294) unniltetradium	121Ufs (294) unnilpentium	122Uht (294) unnilhexium	123Ufl (294) unnilseptium	124Ufh (294) unniloctium	125Ufb (294) unnilenneum	126Uft (294) unnilunium	127Ufl (294) unnilhassium	128Ufh (294) unniltetradium	129Ufb (294) unnilpentium	130Uht (294) unnilhexium	131Ufl (294) unnilseptium	132Ufh (294) unniloctium	133Ufb (294) unnilenneum	134Uft (294) unnilunium	135Ufl (294) unnilhassium	136Ufh (294) unniltetradium	137Ufb (294) unnilpentium	138Uht (294) unnilhexium	139Ufl (294) unnilseptium	140Ufh (294) unniloctium	141Ufb (294) unnilenneum	142Uft (294) unnilunium	143Ufl (294) unnilhassium	144Ufh (294) unniltetradium	145Ufb (294) unnilpentium	146Uht (294) unnilhexium	147Ufl (294) unnilseptium	148Ufh (294) unniloctium	149Ufb (294) unnilenneum	150Uft (294) unnilunium	151Ufl (294) unnilhassium	152Ufh (294) unniltetradium	153Ufb (294) unnilpentium	154Uht (294) unnilhexium	155Ufl (294) unnilseptium	156Ufh (294) unniloctium	157Ufb (294) unnilenneum	158Uft (294) unnilunium	159Ufl (294) unnilhassium	160Ufh (294) unniltetradium	161Ufb (294) unnilpentium	162Uht (294) unnilhexium	163Ufl (294) unnilseptium	164Ufh (294) unniloctium	165Ufb (294) unnilenneum	166Uft (294) unnilunium	167Ufl (294) unnilhassium	168Ufh (294) unniltetradium	169Ufb (294) unnilpentium	170Uht (294) unnilhexium	171Ufl (294) unnilseptium	172Ufh (294) unniloctium	173Ufb (294) unnilenneum	174Uft (294) unnilunium	175Ufl (294) unnilhassium	176Ufh (294) unniltetradium	177Ufb (294) unnilpentium	178Uht (294) unnilhexium	179Ufl (294) unnilseptium	180Ufh (294) unniloctium	181Ufb (294) unnilenneum	182Uft (294) unnilunium	183Ufl (294) unnilhassium	184Ufh (294) unniltetradium	185Ufb (294) unnilpentium	186Uht (294) unnilhexium	187Ufl (294) unnilseptium	188Ufh (294) unniloctium	189Ufb (294) unnilenneum	190Uft (294) unnilunium	191Ufl (294) unnilhassium	192Ufh (294) unniltetradium	193Ufb (294) unnilpentium	194Uht (294) unnilhexium	195Ufl (294) unnilseptium	196Ufh (294) unniloctium	197Ufb (294) unnilenneum	198Uft (294) unnilunium	199Ufl (294) 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unnilunium	239Ufl (294) unnilhassium	240Ufh (294) unniltetradium	241Ufb (294) unnilpentium	242Uht (294) unnilhexium	243Ufl (294) unnilseptium	244Ufh (294) unniloctium	245Ufb (294) unnilenneum	246Uft (294) unnilunium	247Ufl (294) unnilhassium	248Ufh (294) unniltetradium	249Ufb (294) unnilpentium	250Uht (294) unnilhexium	251Ufl (294) unnilseptium	252Ufh (294) unniloctium	253Ufb (294) unnilenneum	254Uft (294) unnilunium	255Ufl (294) unnilhassium	256Ufh (294) unniltetradium	257Ufb (294) unnilpentium	258Uht (294) unnilhexium	259Ufl (294) unnilseptium	260Ufh (294) unniloctium	261Ufb (294) unnilenneum	262Uft (294) unnilunium	263Ufl (294) unnilhassium	264Ufh (294) unniltetradium	265Ufb (294) unnilpentium	266Uht (294) unnilhexium	267Ufl (294) unnilseptium	268Ufh (294) unniloctium	269Ufb (294) unnilenneum	270Uft (294) unnilunium	271Ufl (294) unnilhassium	272Ufh (294) unniltetradium	273Ufb (294) unnilpentium	274Uht (294) unnilhexium	275Ufl (294) unnilseptium	276Ufh (294) unniloctium	277Ufb (294) unnilenneum	278Uft (294) unnilunium	279Ufl (294) unnilhassium	280Ufh (294) unniltetradium	281Ufb (294) unnilpentium	282Uht (294) unnilhexium	283Ufl (294) unnilseptium	284Ufh (294) unniloctium	285Ufb (294) unnilenneum	286Uft (294) unnilunium	287Ufl (294) unnilhassium	288Ufh (294) unniltetradium	289Ufb (294) unnilpentium	290Uht (294) unnilhexium	291Ufl (294) unnilseptium	292Ufh (294) unniloctium	293Ufb (294) unnilenneum	294Uft (294) unnilunium	295Ufl (294) unnilhassium	296Ufh (294) unniltetradium	297Ufb (294) unnilpentium	298Uht (294) unnilhexium	299Ufl (294) unnilseptium	300Ufh (294) unniloctium	301Ufb (294) unnilenneum	302Uft (294) unnilunium	303Ufl (294) unnilhassium	304Ufh (294) unniltetradium	305Ufb (294) unnilpentium	306Uht (294) unnilhexium	307Ufl (294) unnilseptium	308Ufh (294) unniloctium	309Ufb (294) unnilenneum	310Uft (294) unnilunium	311Ufl (294) unnilhassium	312Ufh (294) unniltetradium	313Ufb (294) unnilpentium	314Uht (294) unnilhexium	315Ufl (294) unnilseptium	316Ufh (294) unniloctium	317Ufb (294) unnilenneum	318Uft (294) unnilunium	319Ufl (294) unnilhassium	320Ufh (294) unniltetradium	321Ufb (294) unnilpentium	322Uht (294) unnilhexium	323Ufl (294) unnilseptium	324Ufh (294) unniloctium	325Ufb (294) unnilenneum	326Uft (294) unnilunium	327Ufl (294) unnilhassium	328Ufh (294) unniltetradium	329Ufb (294) unnilpentium	330Uht (294) unnilhexium	331Ufl (294) unnilseptium	332Ufh (294) unniloctium	333Ufb (294) unnilenneum	334Uft (294) unnilunium	335Ufl (294) unnilhassium	336Ufh (294) unniltetradium	337Ufb (294) unnilpentium	338Uht (294) unnilhexium	339Ufl (294) unnilseptium	340Ufh (294) unniloctium	341Ufb (294) unnilenneum	342Uft (294) unnilunium	343Ufl (294) unnilhassium	344Ufh (294) unniltetradium	345Ufb (294) unnilpentium	346Uht (294) unnilhexium	347Ufl (294) unnilseptium	348Ufh (294) unniloctium	349Ufb (294) unnilenneum	350Uft (294) unnilunium	351Ufl (294) unnilhassium	352Ufh (294) unniltetradium	353Ufb (294) unnilpentium	354Uht (294) unnilhexium	355Ufl (294) unnilseptium	356Ufh (294) unniloctium	357Ufb (294) unnilenneum	358Uft (294) unnilunium	359Ufl (294) unnilhassium	360Ufh (294) unniltetradium	361Ufb (294) unnilpentium	362Uht (294) unnilhexium	363Ufl (294) unnilseptium	364Ufh (294) unniloctium	365Ufb (294) unnilenneum	366Uft (294) unnilunium	367Ufl (294) unnilhassium	368Ufh (294) unniltetradium	369Ufb (294) unnilpentium	370Uht (294) unnilhexium	371Ufl (294) unnilseptium	372Ufh (294) unniloctium	373Ufb (294) unnilenneum	374Uft (294) unnilunium	375Ufl (294) unnilhassium	376Ufh (294) unniltetradium	377Ufb (294) unnilpentium	378Uht (294) unnilhexium	379Ufl (294) unnilseptium	380Ufh (294) unniloctium	381Ufb (294) unnilenneum	382Uft (294) unnilunium	383Ufl (294) unnilhassium	384Ufh (294) unniltetradium	385Ufb (294) unnilpentium	386Uht (294) unnilhexium	387Ufl (294) unnilseptium	388Ufh (294) unniloctium	389Ufb (294) unnilenneum	390Uft (294) unnilunium	391Ufl (294) unnilhassium	392Ufh (294) unniltetradium	393Ufb (294) unnilpentium	394Uht (294) 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